

# Performance of the TGRS Radio Occultation Instrument

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Tom Meehan

J.Tien, M. Roberts, C.Ao, E.Wang

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA USA

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# Summary

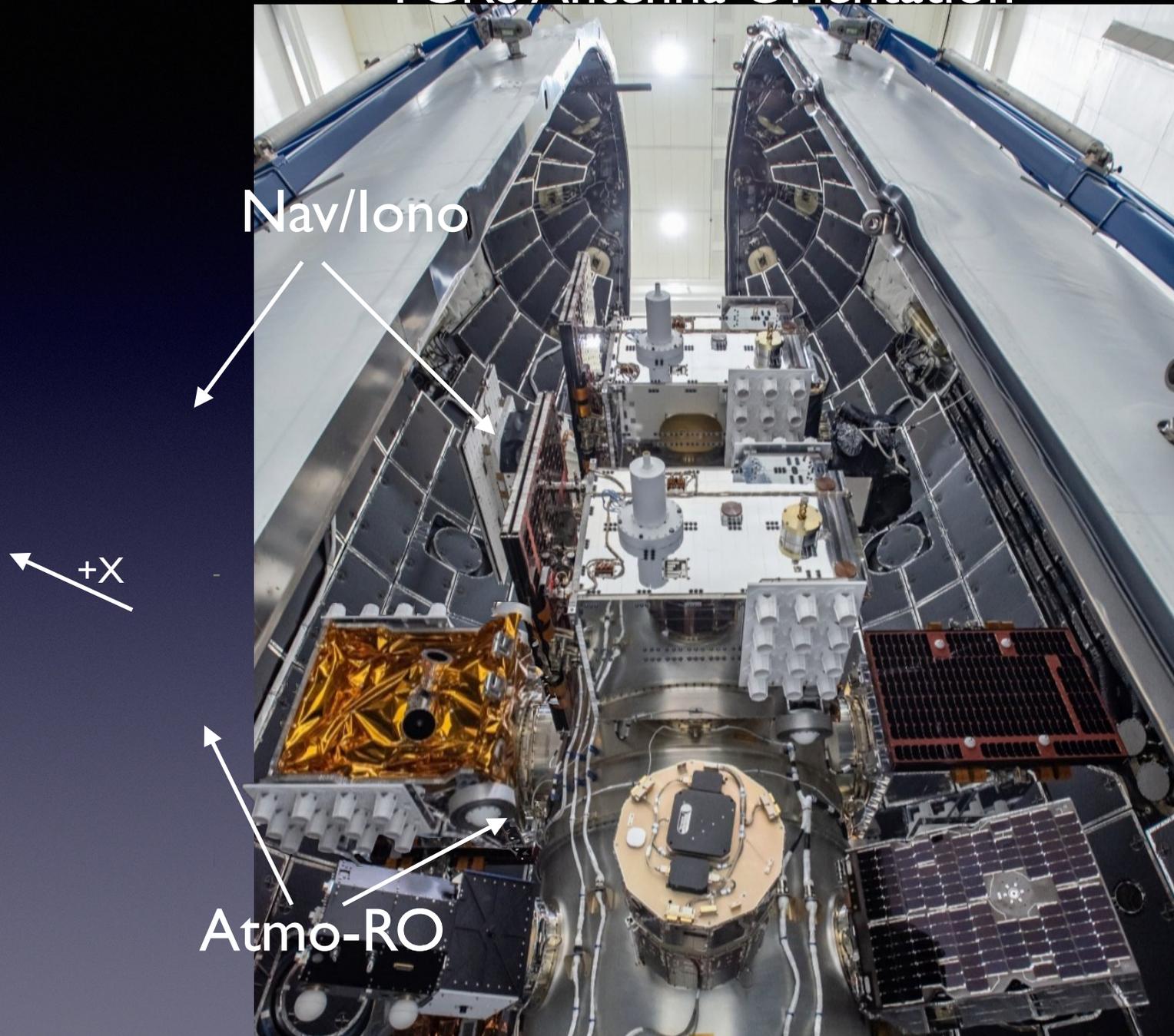


- TGRS per COSMIC-2
- Space Weather
- Neutral Atmosphere
- Additional Work



- Oscillator
- POD
- On-board Nav
- SEU Effects

## TGRS Antenna Orientation



## TGRS / C-2 Key Reqs



- 1015 Ionospheric Occultations / Day  
Settable Azim, Altitude Range
- 550 Ionospheric Arcs / Day\*
- High-rate ( $\geq 50$  Hz) S4, L1, L2 Phase  
& Power over Ionospheric Occ Region
- POD ( $\sim 10$ cm, 0.1mm/sec)
- 1100 Atmospheric Occultations / Day  
Settable Azimuth, Altitude Range, BF

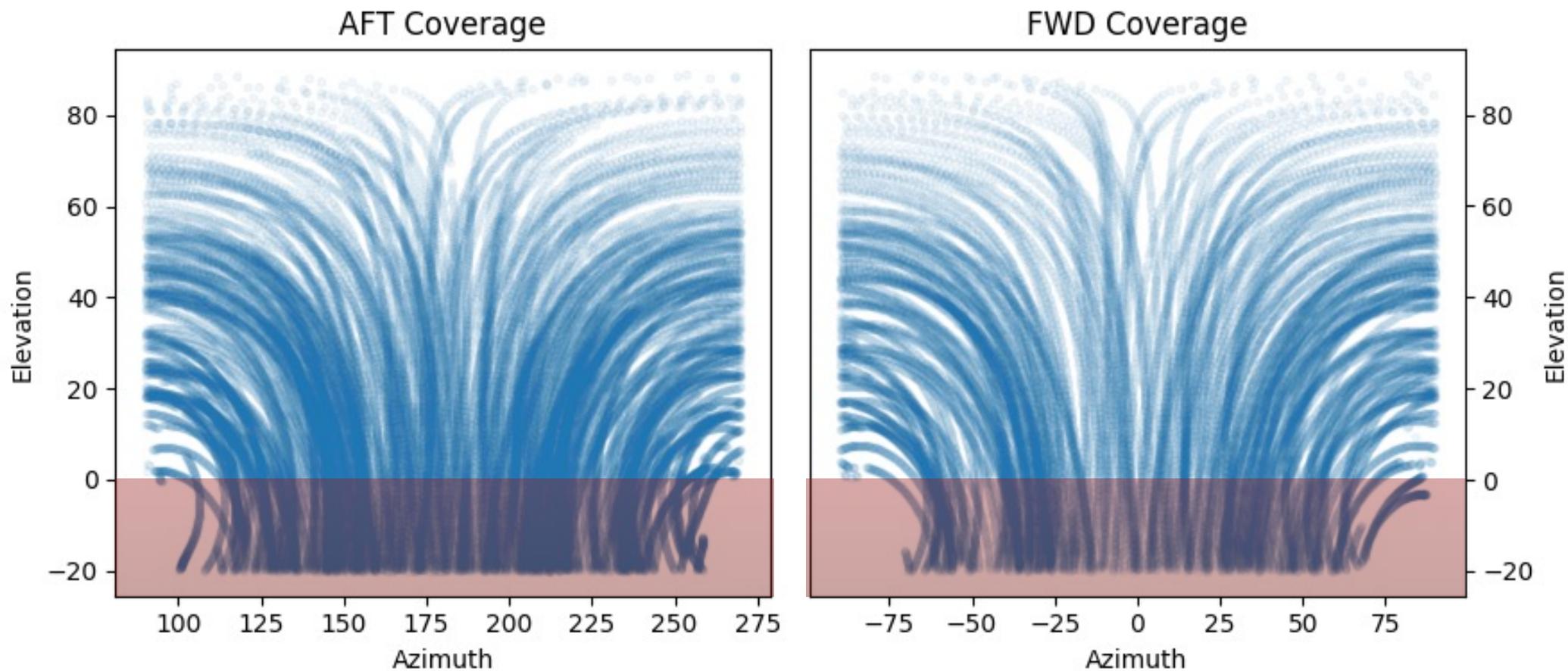


## Space Weather Instrument

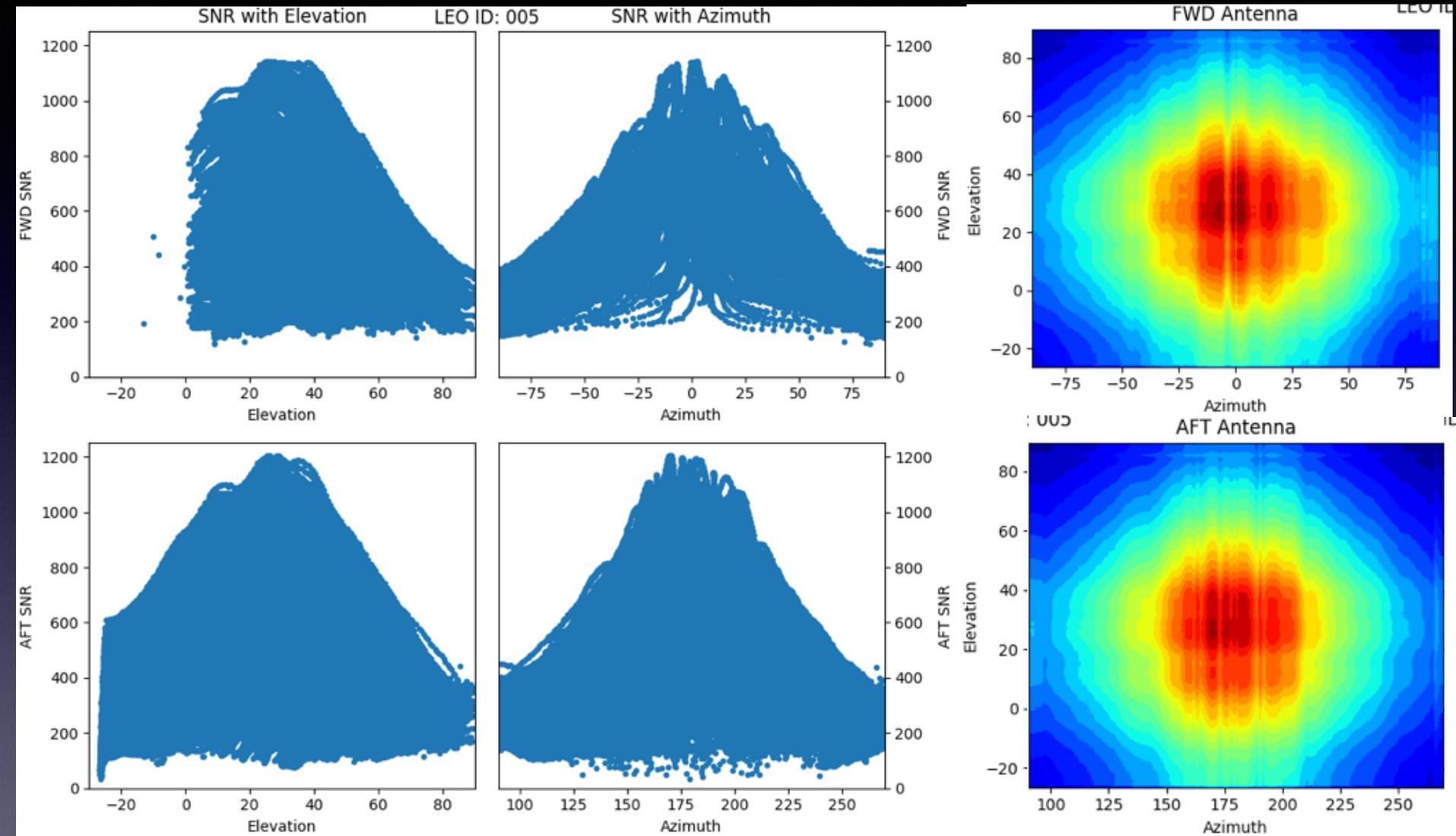
- Fore/aft Navigation Antennas Used for Space Weather
- ~1000 GPS / GLONASS Ionosphere Occultations (550 km - 60 km) per Day
- Phase/Range at 1-sec. S4 every 10-sec based on 50 Hz (GPS) or 100 Hz (GLO)
- All GLONASS processed open-loop
- High-rate scintillation data can be produced either by schedule or by triggering above settable S4 levels

# TGRS / C-2

## GPS Ionosphere Coverage

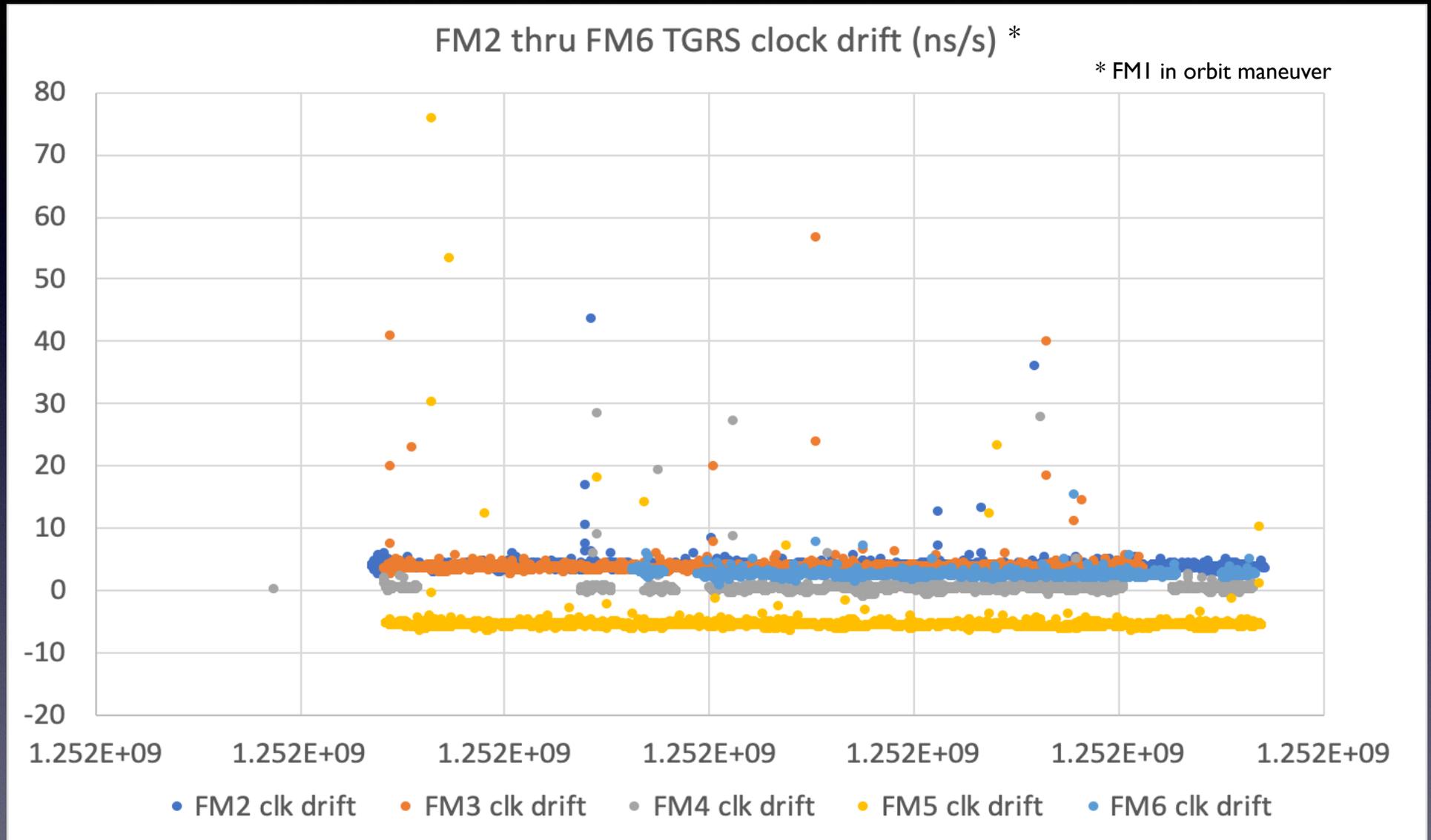


# POD/Iono Antenna Performance





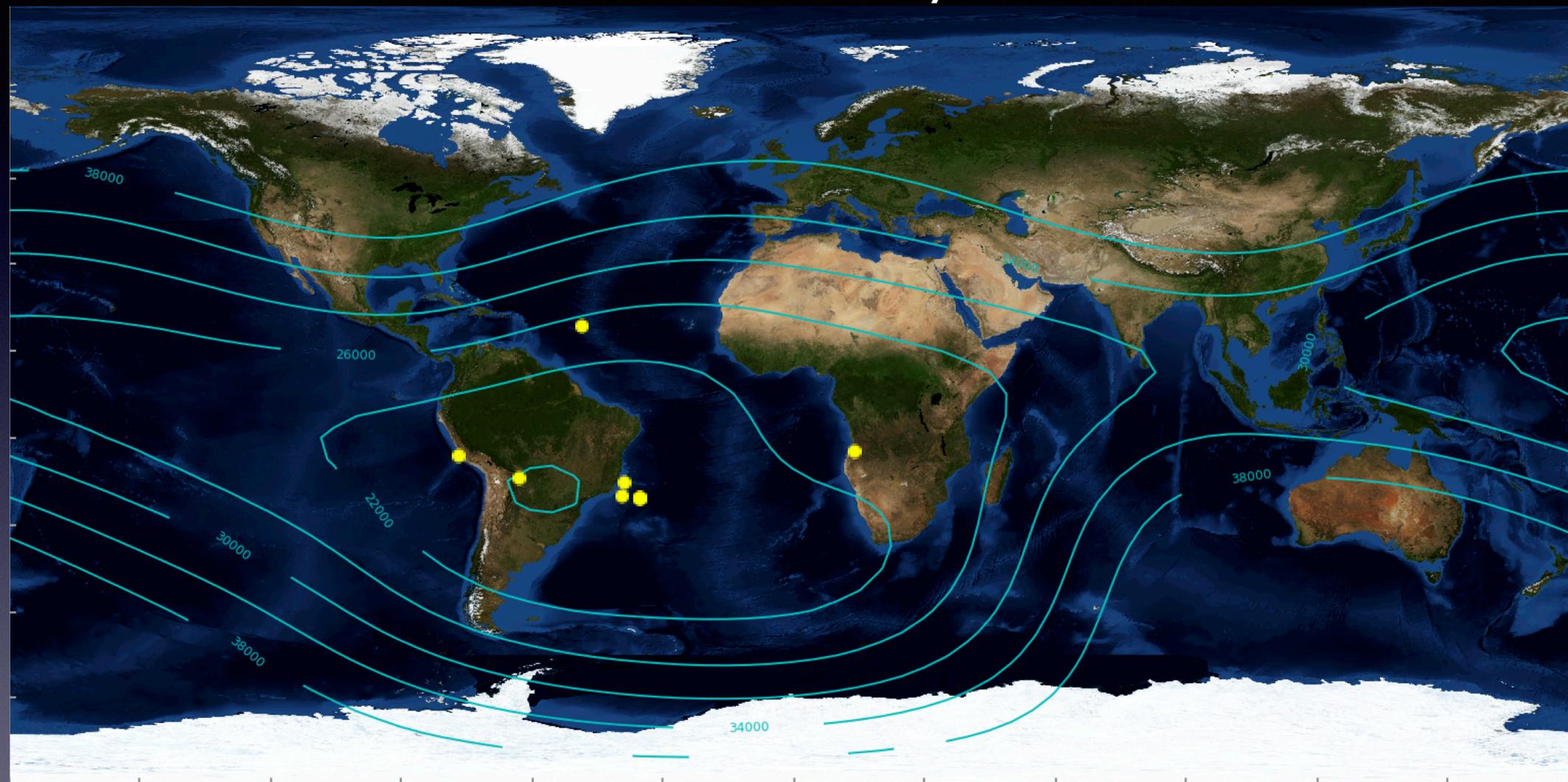
# TGRS Oscillator Drift



# TGRS / C-2

## Single-event Effects

### FM1 over 3 Days





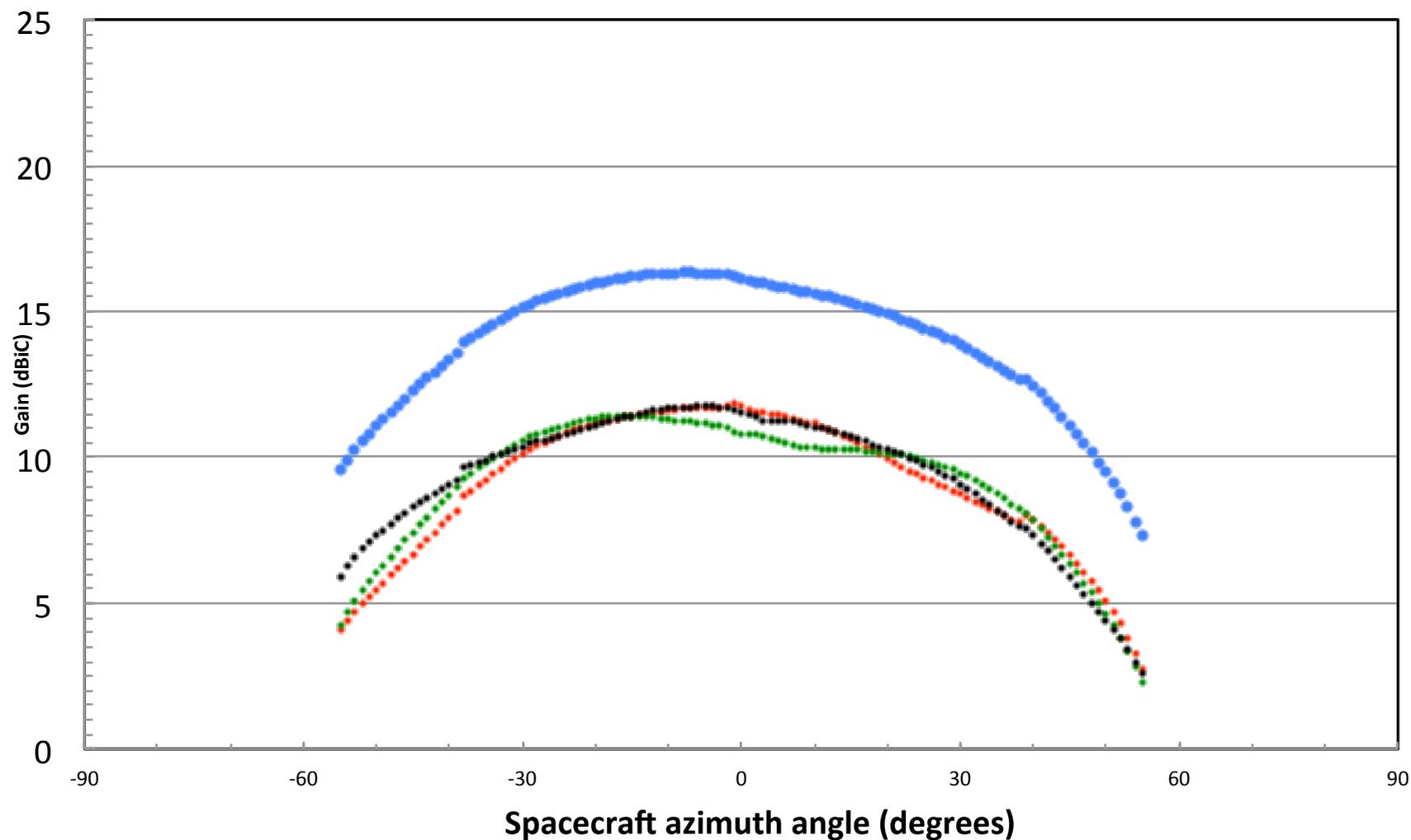
## RO Antenna with Beam Forming

- **Fore/Aft Orientation Phased Towards Earth Limb**
- **Wide-band to accept all GNSS**
- **Expect >2x Better Precision ( COSMIC-1 )**

## RO Beam forming performance

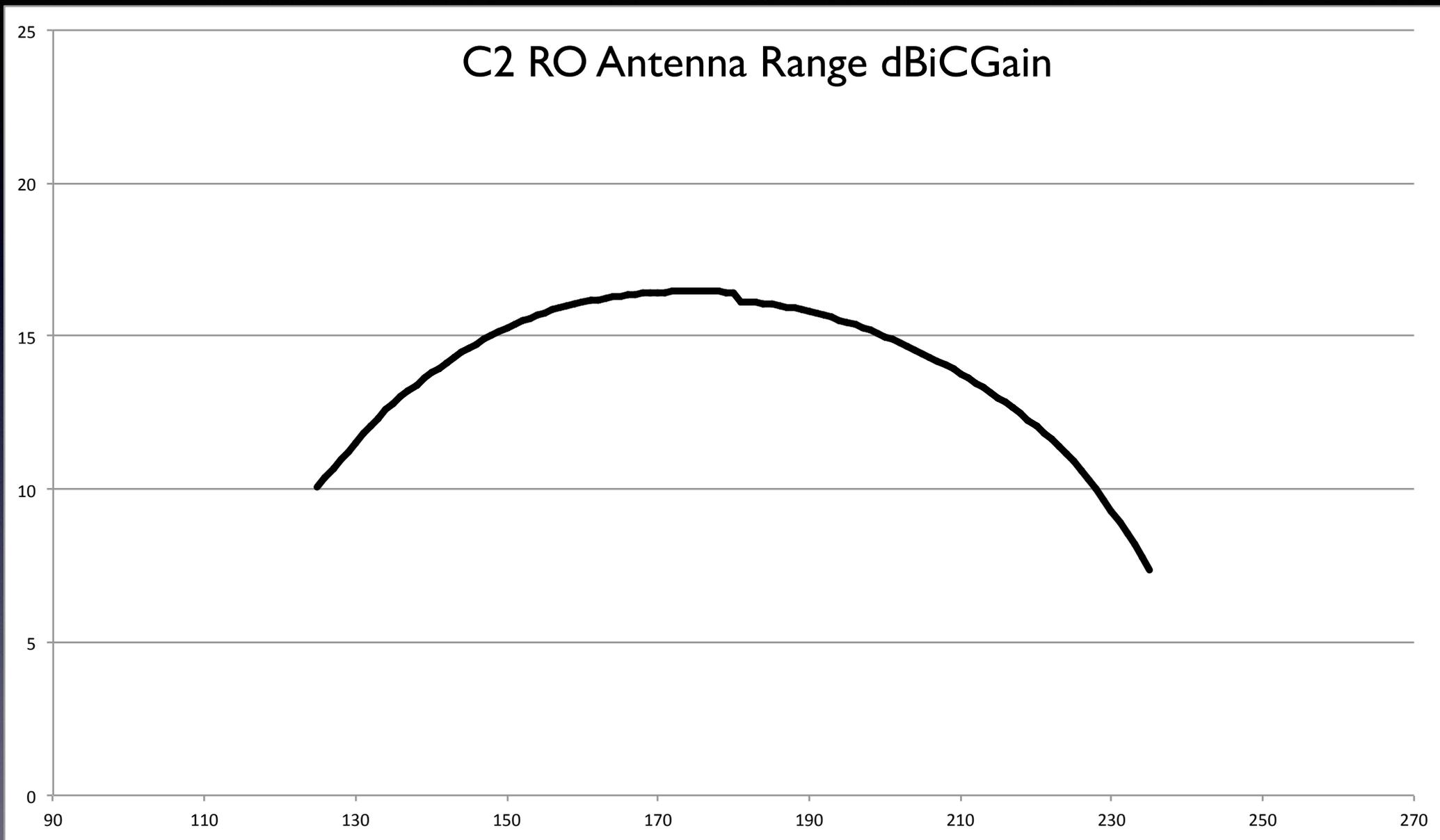
## Gain of Subarrays As a Function of Azimuth, GPS L1 Frequency

• Sub 1 -20°   • Sub 2 -20°   • Sub 3 -20°   • Composite -20°



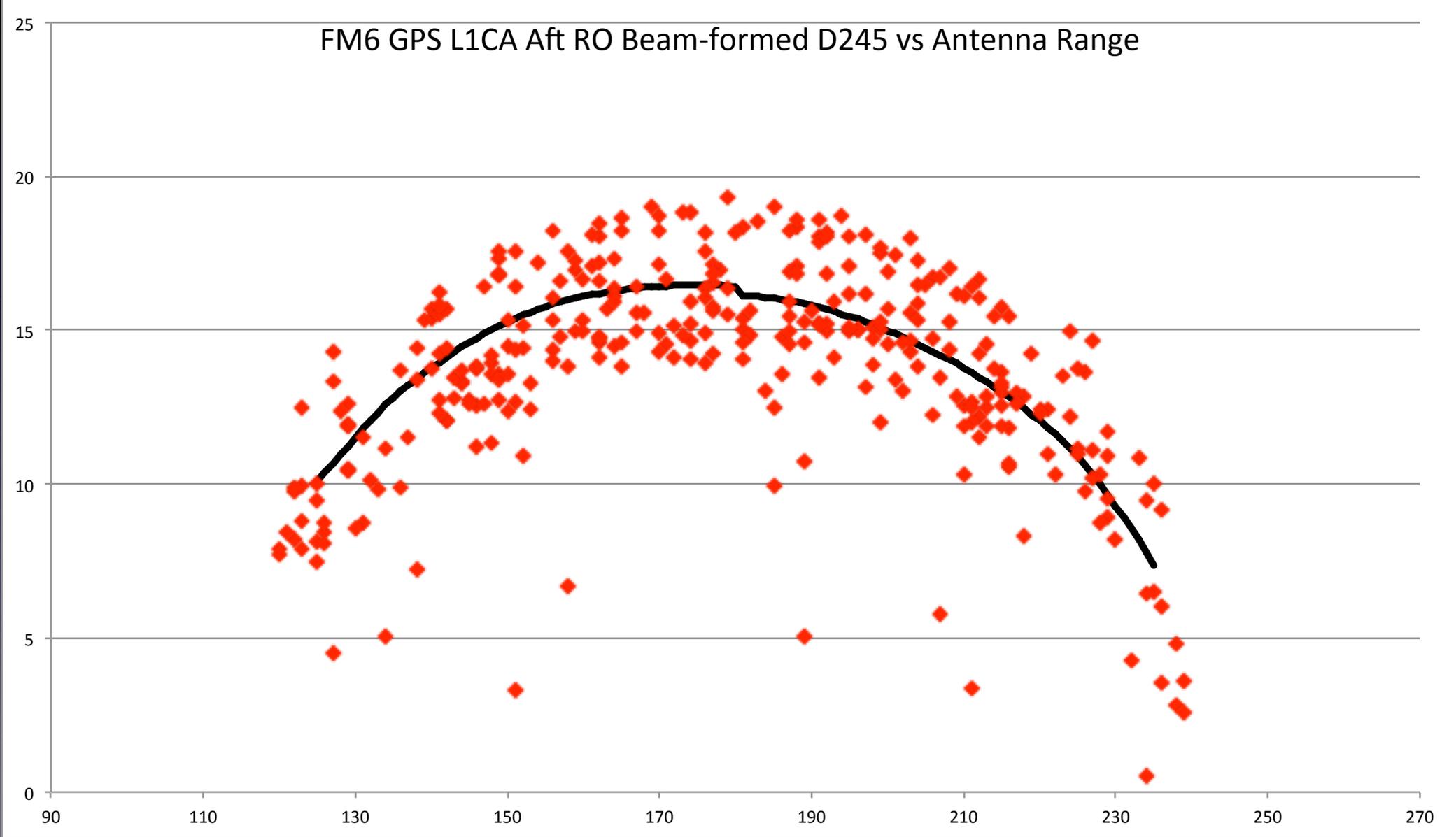
## TGRS / C-2

## RO Beam forming performance





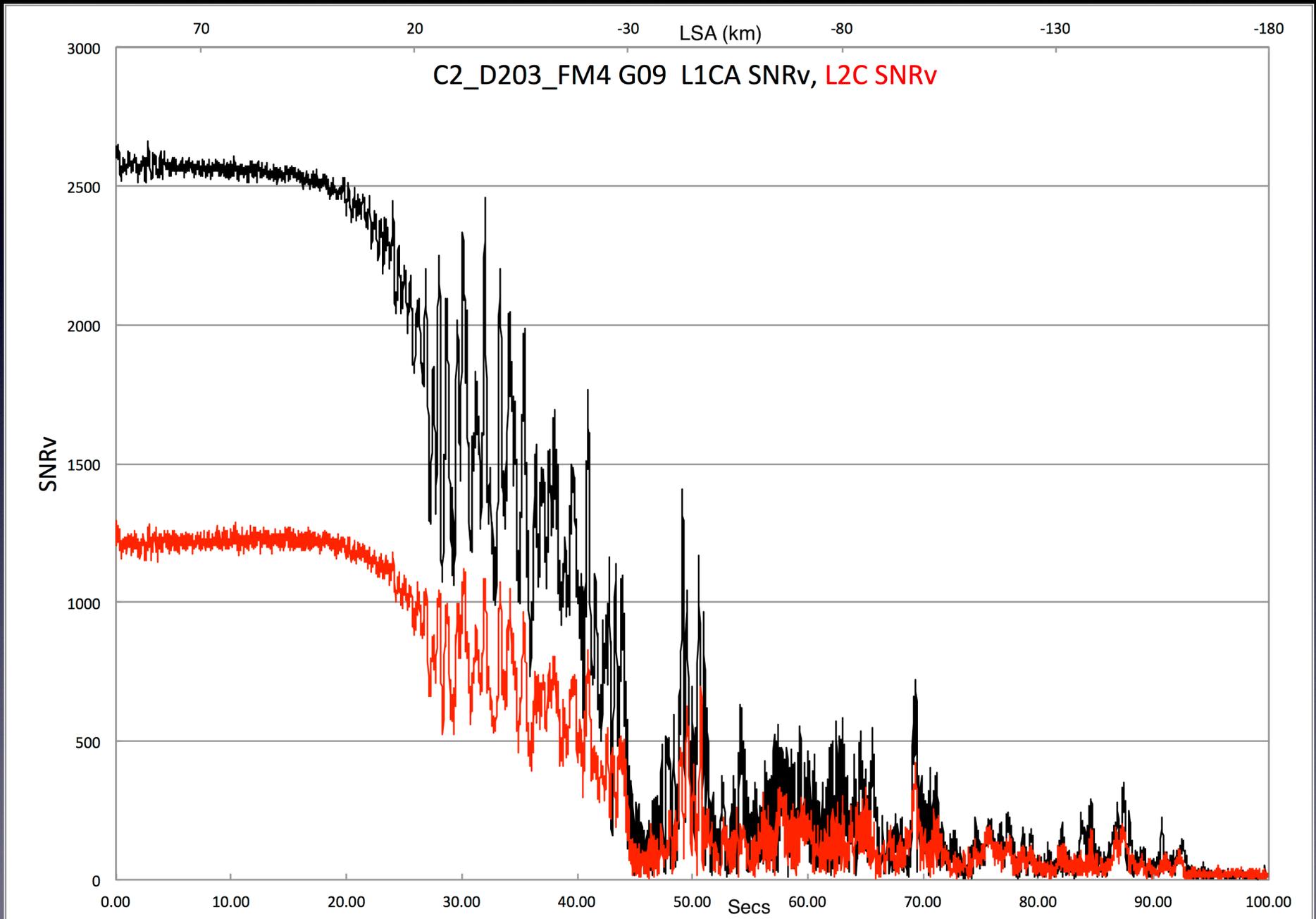
# RO Beam forming performance





# TGRS / C-2

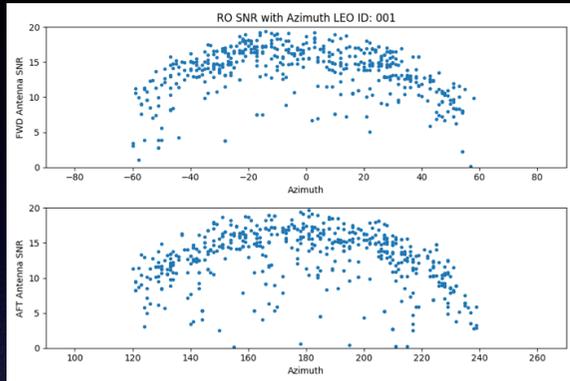
## RO Beam Forming Performance



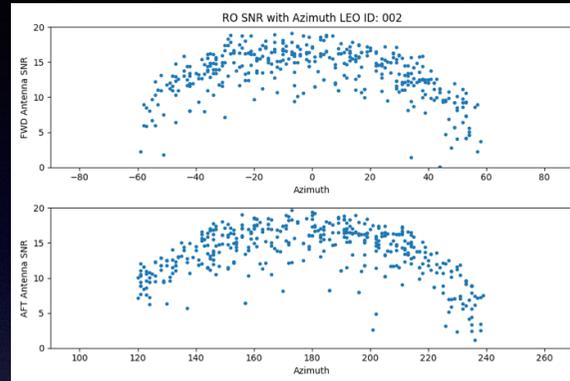


# All 6 TGRS, Fore/Aft, Beam forming is ON Consistent SNRs

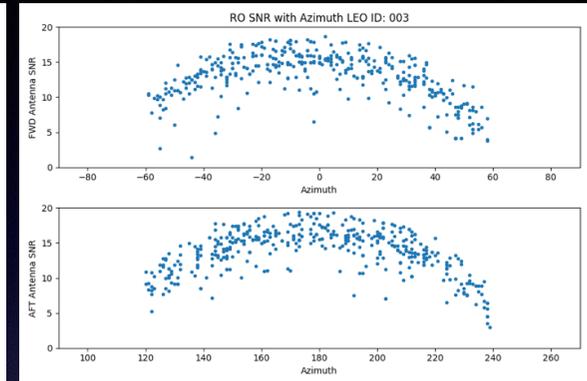
FM1



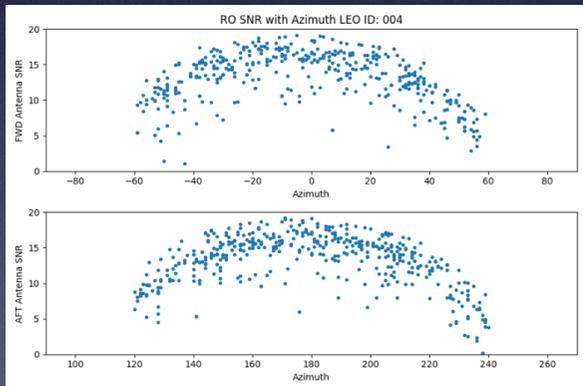
FM2



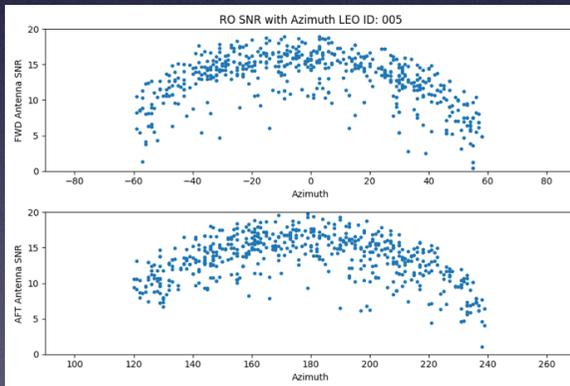
FM3



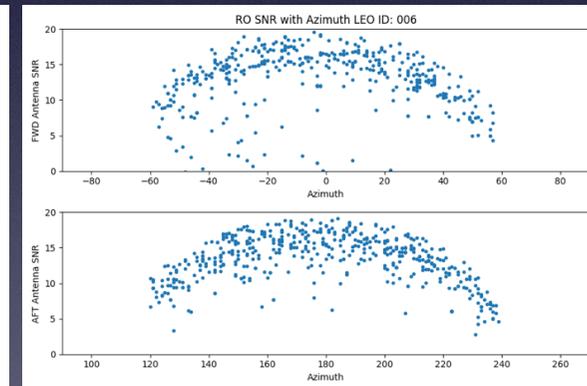
FM4



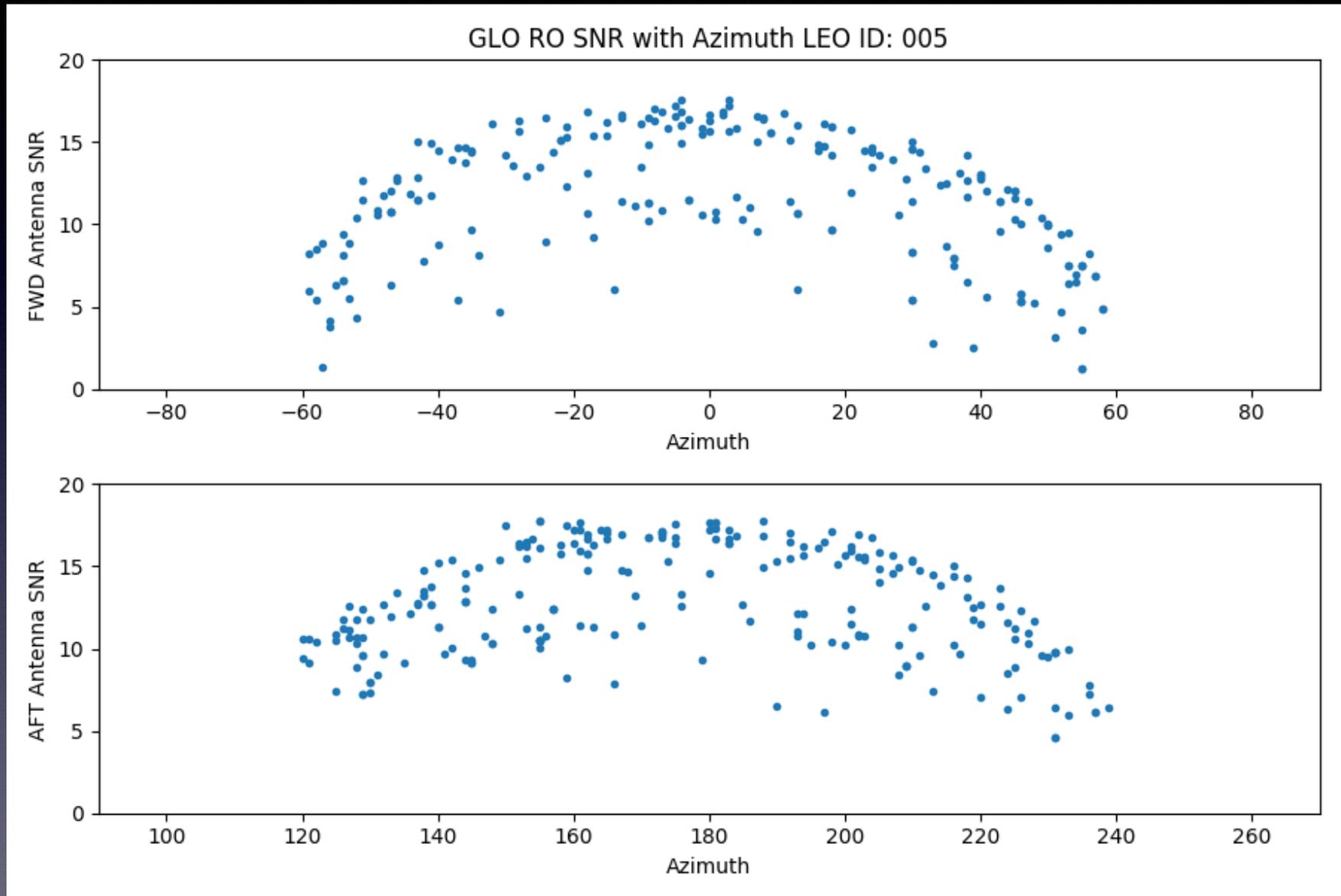
FM5



FM6



## GLONASS RO L1 Gain Similar to GPS

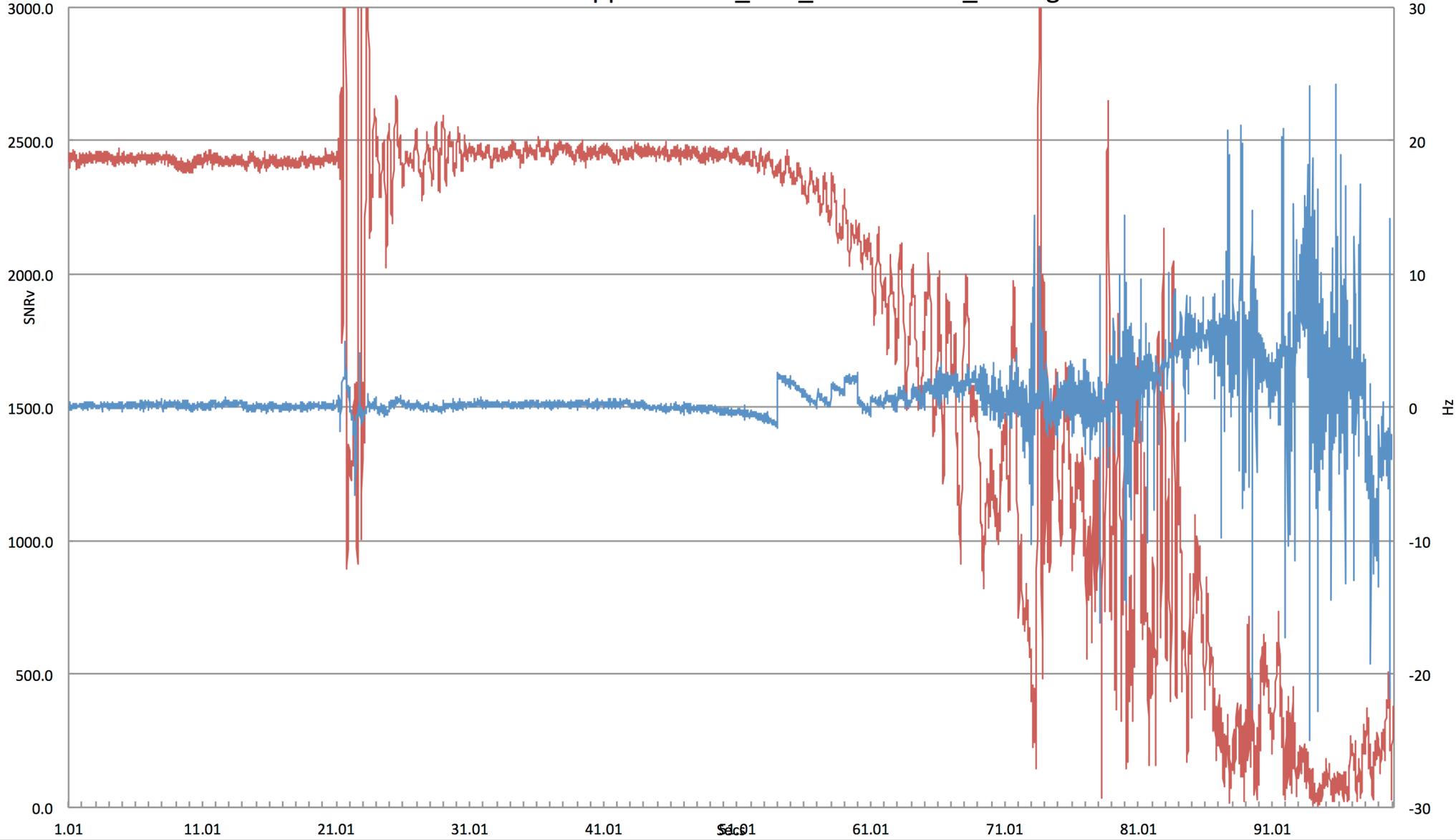




# TGRS / C-2

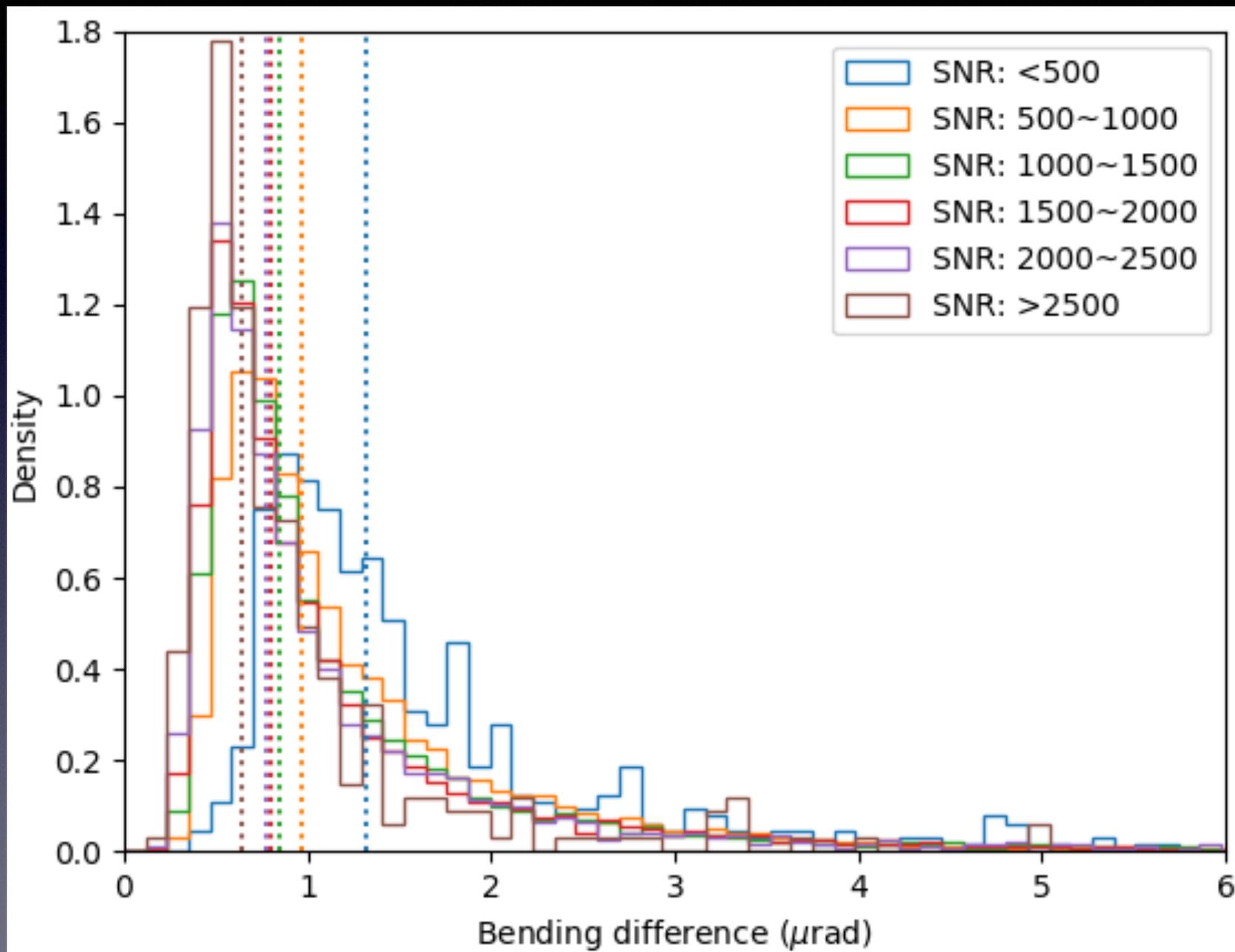
## RO Frequency Model Check

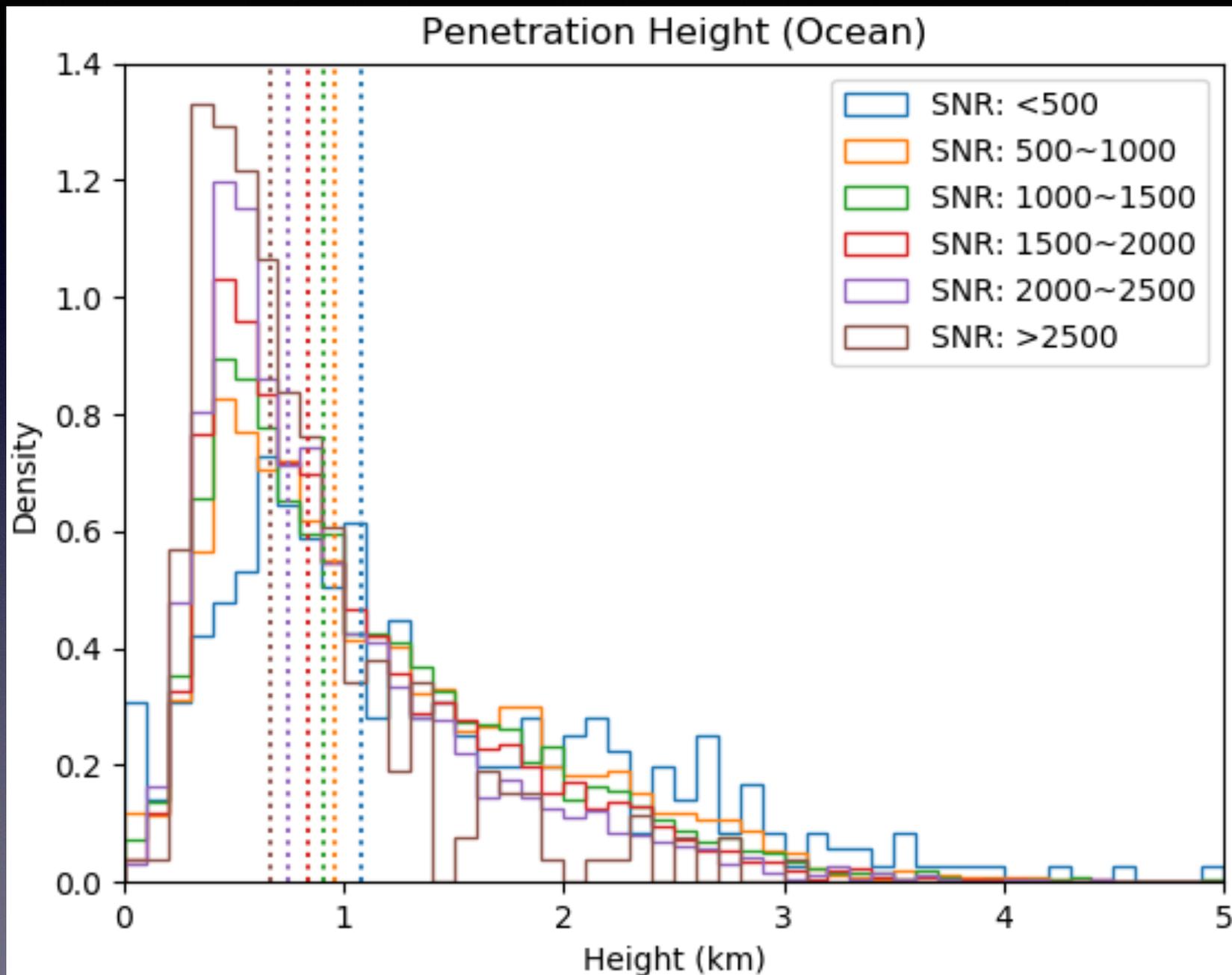
SNR & Residual Doppler FM2\_G12\_1248728437\_Setting



# TGRS / C-2

## Usable Precision





# TGRS / C-2 Assessment



Thus far, all 6 TGRS show:

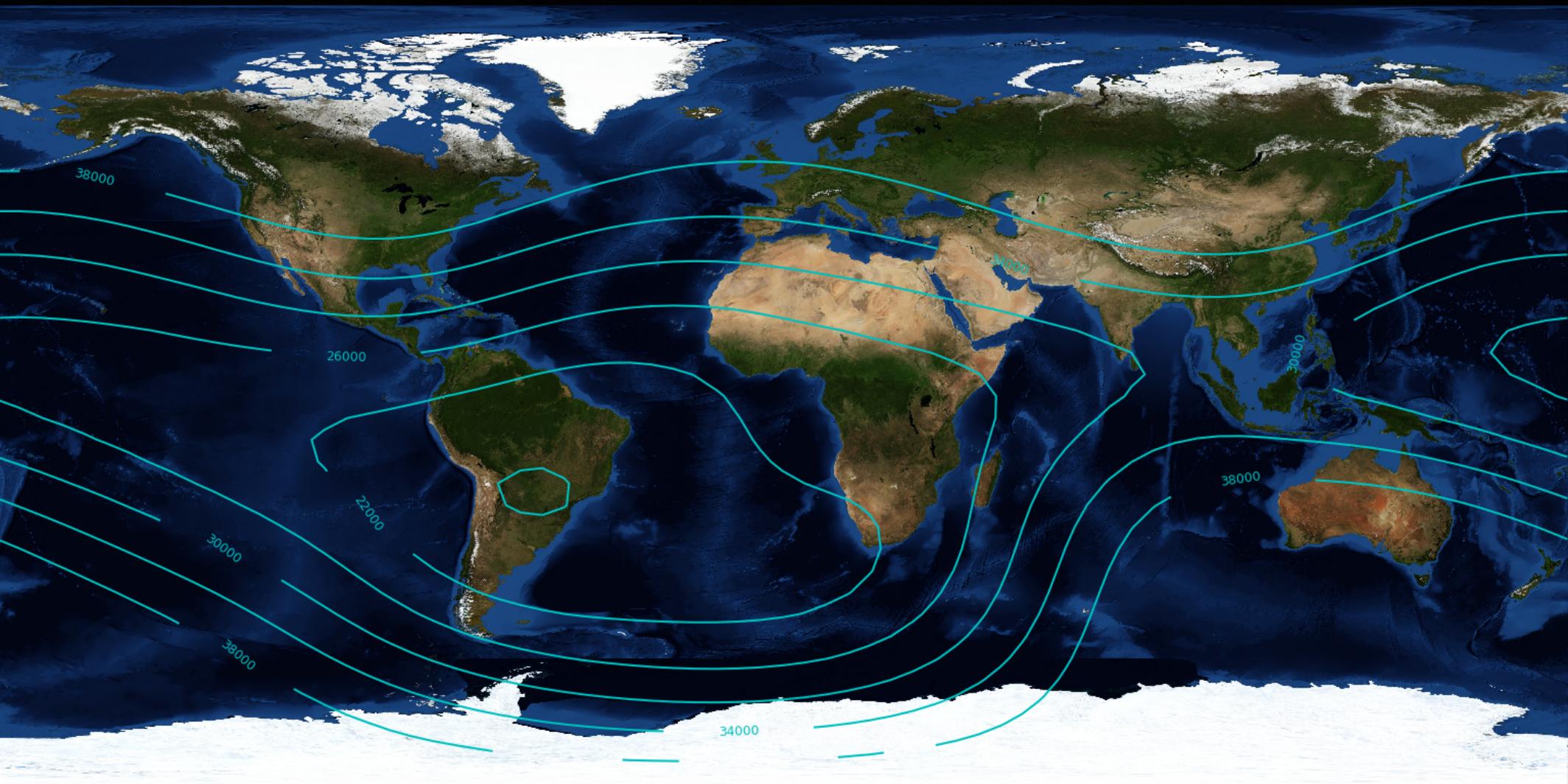
- Stable Oscillator Performance
- Excellent SEU Tolerance
- Expected SNRs for Nav/POD
- Expected POD Accuracy
- Expected OL Model Accuracy
- High RO SNR Over Required Azimuth Range



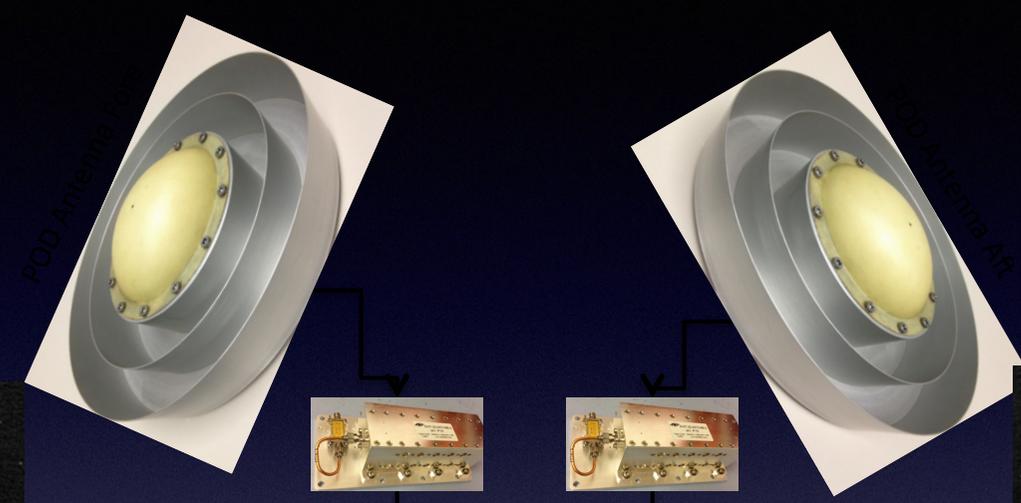
# Thank You



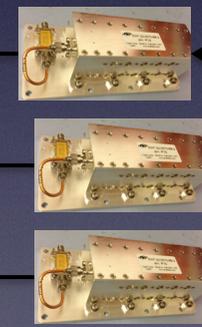
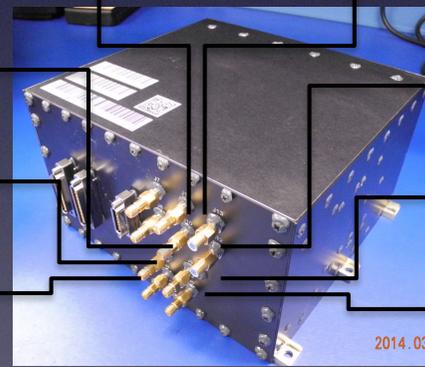
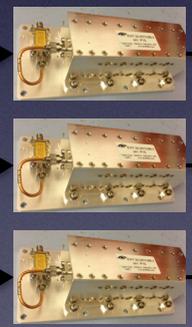
# TGRS / C-2



# TGRS Refresher



Filter/LNA  
Assemblies (8)



RO Antenna Fore

RO Antenna Aft